CERTIFICATE OF VERIFICATION

I, Soo Jin KIM of 648-23 Yeoksam-dong, Gangnam-gu, Seoul, Republic of Korea state that the attached document is a true and complete translation to the best of my knowledge of the Korean-English language and that the writings contained in the following pages are correct English translation of the specification and claims of the Korean Patent Application No. 10-1999-0011024.

Dated this 30th day of January, 2007.

Signature of translator: ______________________

Soo Jin KIM

KOREAN INTELLECTUAL PROPERTY OFFICE

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Date of Application : Mar 30, 1999

Applicant(s) : LG Electronics Inc.

COMMISIONER

[ABSTRACT OF THE DISCLOSURE]

[ABSTRACT]

The present invention relates to a tilt controlling method for detecting and compensating tilt of an optical record medium in a high-density optical recording medium system. Since read channel 2 signals detected VFO1 and VFO areas of the header 1,3 field staggered with respect to each other has constant magnitude and shifts above/below the track center, the magnitude and the direction of tilt can be detected and compensated by comparing potential difference between the track center and VFO1 signal with potential difference between the track center and VFO3 signal. Therefore, tilt can be detected and compensated in a stable and accurate manner without using a separate light-receiving element in a high-density optical disc and deterioration of data quality caused by tilt during a recording/reproducing operation can be prevented and stable operation of the system can be possible.

[TYPICAL DRAWING]

<tilt, detrack offset, defocus offset>

[INDEX WORDS]

tilt

[SPECIFICATION]

[TITLE OF THE INVENTION]

METHOD FOR TILT CONTROLLING

[BRIEF DESCRIPTION OF THE DRAWINGS]

FIG. 1 is a diagram showing an arrangement of a header preformatted at the beginning position of each sector in a general rewritable disc.

FIG. 2 is a block diagram showing a structure of an optical disc recording/reproducing apparatus for controlling tilt in accordance with the present invention.

FIG. 3 is an exemplary diagram showing an optical detector of the optical pickup shown in FIG. 2.

FIG. 4 is an exemplary graph showing read channel 2 signals detected at VFO1 and VFO3 areas in the header field depending on variation of a tilt.

FIGS. 5a to 5c are exemplary diagrams showing the potential relationship between the read channel 2 signals detected at VFO1 and VFO3 areas in the header field and a track center, depending on variation of tilt.

FIG. 6a to 6c are exemplary diagrams showing the relationship between the read channel 2 signals detected at VFO1 and VFO3 areas in the header field and a ground level, depending on variation of tilt.

***Reference numerals of the essential parts in the**

drawings*

201 : optical disc

202 : optical pickup

203 : RF signal and servo error signal generator

204 : tilt detector

205 : servo controller

206 : tilt operator

[DETAILED DESCRIPTION OF THE INVENTION]

[OBJECT OF THE INVENTION]

[FIELD OF THE INVENTION AND DISCUSSION OF THE RELATED ART]

The present invention relates to a high-density optical recording medium system, and more particularly, to a method for controlling tilt, capable of detecting and compensating for tilt of the optical recording medium.

In general, an optical recording medium is divided into a ROM-type for read-only, a WORM-type for rewritable only one time, and a rewritable-type for recording repetitively.

Among them, a repetitively and freely rewritable optical recording medium, for example, an optical disc includes rewritable compact disc (CD-RW) and rewritable digital versatile disc (DVD-RW, DVD-RAM).

These rewritable optical mediums, particularly, optical discs have signal tracks made up of lands and

grooves and enable the tracking control of an empty disc on which no information signal is written. Recently, information signals are also written on the tracks of lands and grooves so as to enhance recording density. For this purpose, the recent optical pickup for recording and reproducing information signals uses the shorter wavelength of laser beam with an increased number of apertures formed in the object lens and thereby reduces the size of beam for recording/reproducing.

In order to achieve higher recording density, such a rewritable high-density optical disc is designed to have a reduced distance between the signal tracks, i.e., the smaller signal track pitch.

For the rewritable discs, it is naturally impossible to perform a disc control and a recording operation in an empty disc in which no information is written. Thus disc tracks are formed in lands and grooves to write information on, and control information for random access and rotation control is separately recorded in the disc, so as to enable tracking control in the empty disc.

The control information is, as shown in FIG. 1, written on the header pre-formatted at the beginning position of each sector, or along the track in the wobbling profile. The term "wobbling" as used herein

refers to recording the control information on the boundary of tracks in accord to variation of laser beam by supplying power of laser diodes with information for modulating a predetermined clock and applying the modulated clock to the disc, e.g., information about a desired position and the rotational speed of the disc.

The header preformatted at the beginning position of each sector includes four header fields (header 1 field, header 2 field, header 3 field and header 4 field). Each header field has variable frequency oscillator (VFO) areas for generating a reference clock to acquire bit synchronization of read channels. In the present invention, the VFO areas present in the respective header fields (header 1 field ~ header 4 field) are called VFO1 ~ VFO4.

That is, VFO1 and VFO 3 areas are present in the header 1 field and the header 3 field, VFO2 and VFO4 areas being in the header 2 field and the header 4 field. The VFO1 and VFO3 areas are longer and more stable for signal detection than the VFO2 and VFO4 areas.

At this time, the four header fields are staggered with respect to each other from the track center. FIG. 1 shows an example of the header for the first sector in a track. Referring to FIG. 1, the track boundary of the user area in which data are actually written has a wobbling profile.

During a resin extracting and gardening process in fabrication of the optical disc, distortion may take place in the optical disc and cause eccentricity even when a central aperture is perforated in optical disc. Also, deviation of the central aperture causes eccentricity although the tracks of the disc are accurately provided in the radial form with a defined pitch. Thus as the disc turns with eccentricity, the central axis of the motor is not in perfect accord with the center of the track.

It is thus hard to read out the signals of a desired track only. So, in the CD and DVD systems, a tracking servo is performed according to the standards established for the deflected quantity such that the beam always traces the desired track in spite of eccentricity.

It means, the tracking servo generates electrical signals corresponding to the beam trace status and moves the object lens or the optical pickup body in the radial direction based on the generated electrical signals, to change the position of the beam and make the beam trace the accurate track.

Meanwhile, the beam can be deflected from a desired track due to a tilt of the disc as well as the eccentricity. This results from a mechanic error occurring when the disc is set on a spindle motor. That is, the focusing direction is not in perpendicular relation with

the tracking direction. This slant state of the disc is called "tilt".

Tilt is not so significant for compact discs that have a large tilt margin due to their wide track pitch. The term "tilt margin" as used herein refers to a compensable quantity of tilt of the disc. However, with a growing need of densification of the optical appliances such as optical discs, especially in the DVD having the narrower track pitch, a slight tilt of the disc causes the beam to shift to the adjacent track due to a small radial tilt margin for the fitter. This detrack is unavoidable by the tracking servo only. That is, the tracking servo may mistake that the beam is tracing the accurate track even when the beam is shifted to the adjacent track due to tilt, while focusing on the center of the track.

This makes it impossible to read data accurately when reproducing, and to write data accurately in a desired track when recording. Thus a double distortion occurs when reproducing the erroneously written data.

[TECHNICAL TASKS TO BE ACHIEVED BY THE INVENTION]

To cope with this problem, there has been suggested a method in which the tilt of the disc can be detected with a dedicated tilt sensor, e.g., a tilt light-receiving device in an optical pickup. However, the method is not so

efficient with a large size of the set.

Accordingly, the present invention is directed a method for tilt controlling that substantially obviates one or more problems due to limitations and disadvantages of the related art.

An object of the present invention is to provide a method for tilt controlling, capable of detecting and adjusting for tilt from potential difference between a track center and read channel 2 signals detected VFO1 and VFO3 areas in the header field.

Another object of the present invention is to provide a method for tilt controlling, capable of detecting and adjusting for tilt from potential difference between a ground level and read channel 2 signals detected in the header field.

[SYSTEM AND OPERATION OF THE INVENTION]

To achieve the above objects of the present invention, in an optical recording/reproducing system in which a wobble signal is recorded on the boundary of tracks and header is staggered with respect to each other from the track center at the beginning position of each sector, a tilt controlling method according to the present invention includes the steps of: determining a potential difference between the track center and a signal detected

from a 1 header; determining a potential difference between the track center and a signal detected from a 2 header staggered with the 1 header; and detecting tilt value from the potential differences obtained at the above steps and performing a tilt servo based on the resulting value.

The signal detected from the 1 header is a read channel 2 signal detected from VFO1 in a header 1 field.

The signal detected from the 2 header is a read channel 2 signal detected from VFO3 in a header 3 field.

The potential of the track center is detected from a wobble signal detected from the read channel 2 signal.

The tilt servo step is applied for compensating tilt by detecting the magnitude of tilt from differential signal of the potential differences obtained from the steps, respectively.

The tilt servo step is applied for compensating tilt by detecting the direction of tilt from the sign of differential signal of the potential differences obtained from the steps, respectively.

The tilt servo step compensates tilt in a direction as to equalize the level of the first potential difference and the second potential difference.

A tilt controlling method according to the present invention includes the steps of: determining whether a

read channel 2 signal detected from each header field staggered with respect to each other from the track center is symmetric relation with respect to the track center value; and performing a tilt servo based on the level of asymmetry if it is determined to be asymmetric at the above step.

The determination step uses the read channel 2 signals detected from VFO areas of the header 1 and 3 field for determining symmetry or asymmetry.

A tilt controlling method according to the present invention includes the steps of: obtaining potential difference between a ground level and a read channel 2 signal detected from the header field based on a status that tilt does not occurred and setting the potential difference as a reference value; obtaining potential difference between a ground level and a read channel 2 signal at need and comparing the potential difference with the reference value; and performing a tilt servo based on the resulting value.

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

The present invention is directed to detection and compensation the magnitude and the direction of tilt by using the characteristic of read channel 2 signals

detected from the header 1 and 3 fields staggered with respect to each other that the magnitude is constant but shifts above/below the track center.

FIG. 2 is a block diagram showing the structure of an optical disc recording/reproducing apparatus for performing tilt control method according to the present invention, in which only the principal parts related to tilt are shown.

Referring to FIG. 2, the optical disc recording/reproducing apparatus includes: a rewritable optical disc (201); an optical pickup (202) for recording/reproducing information on the optical disc (201); an error signal generator (203) for generating an RF signal and a servo error signal from electrical signals output from the optical pickup (202); a tilt detector (204) for detecting a magnitude and the direction of tilt from read channel 2 signals of the error signal generator (203); a servo controller (205) for generating a tilt driving signal from the magnitude and the direction of tilt detected from the tilt detector (204); and a tilt driver (206) for controlling the optical pickup (202) based on the tilt driving signal to compensate for the tilt. Herein, the tilt driver (206) is a tilt servo mechanism for correcting tilt by moving an optical pickup or a disc itself.

Herein, the optical pickup (202) has a split photo detector for detecting the quantity of light and converting the detected quantity of light to electrical signals. The split photo detector can be divided, as shown in FIG. 3, into a predefined number of optical detecting elements, e.g., four optical detecting elements PDA, PDB, PDC and PDD in the signal track direction and the radial direction of the optical disc (201).

In the present invention as constructed above, the optical disc (201) has signal tracks made up of lands and grooves, and data can be recorded/reproduced on the tracks of both the lands and the grooves as well as either the land tracks or the groove tracks. Also, at the beginning position of each sector, header 1 and 2 fields and header 3 and 4 fields are staggered with respect to each other in a free format. That is, the phases of the header 1 and 2 fields are in inverse relation with those of the header 3 and 4 fields.

Thus, while setting the optical disc (201), or during the recording/reproducing operation, the laser beam emitted from a laser diode of the optical pickup (202) is directed onto the signal tracks of the optical disc (201) and the beam reflected from the signal tracks of the optical disc (201) enters the split photo detector.

The split photo detector includes a plurality of

optical detecting elements and outputs to the error signal generator (203) electrical signal proportional to the quantity of beam obtained from the respective optical detecting elements.

The optical detector, if constructed as shown in FIG. 3, outputs to the error signal generator (203) electrical signals a, b, c and d, each in proportion to the quantity of beam obtained from the respective optical detecting elements PDA, PDB, PDC and PDD.

The error signal generator (203) combines the electrical signals a, b, c and d to generate a read channel 1 signal (or an RF signal) necessary for data reading, and a read channel 2 signal and a focus error signal, which are all necessary for a servo control. The read channel 2 signal is obtained by combining the electrical signals as (a+d)-(b+c). The tracking error signal is obtained by processing the read channel 2 signal through filtering.

The split photo detector, if divided into two photodiodes (I1 and I2), detects the read channel 2 signal (=I1-I2) from the beam quantity balance of both photodiodes. That is, in FIG. 3, a+d corresponds to I1 and b+c corresponds to I2.

Here, a wobble signal written on each track as shown in FIG. 1 is detected only from the read channel 2

signal.

The track center value is best detected from wobble signals, since the wobble signals are formed regularly along the track boundary during fabrication of the disc and tilt does not affect the center of the wobble signals.

Thus the present invention detects tilt using a level difference between VFO1 and VFO3 signals at the header field of read channel 2 and the track center. The reason for using signals of VFO1 and VFO3 areas in the header field lies in that the VFO1 and VFO3 areas are the longest and most stable areas in the header field and easy to detect.

For this, among error signals detected at the error signal generator (203), read channel 2 signals are input to the tilt detector (204).

The levels of read channel 2 signals detected at VFO1 and VFO3 areas appear negligible due to variation of tilt with focus and tracking on, as shown in Table 1.

[Table 1]

Radial Tilt [°]	VFO1 [V]	VFO3 [V]
-1.0	0.201	0.178
-0.8	0.215	0.183
-0.6	0.210	0.187
-0.4	0.197	0.187
-0.2	0.197	0.201
0.0	0.192	0.206
0.2	0.210	0.178
0.4	0.151	0.224
0.6	0.127	0.219
0.8	0.110	0.215
1.0	0.114	0.197

FIG. 4 is a graph illustrating Table 1, in which the two signals are almost constant in level VFO1-VFO3≈0.

That is, the signal levels are constant within the range of $V_{k-} \leq VFO1+VFO3 \leq V_{k+}$ irrespective of tilt.

As shown in FIGS. 5a to 5c, the VFO1 and VFO3 signals are shifted above/below the track center due to variation of tilt. However, tilt does not affect the track center.

Thus the quantity (=magnitude) and the direction of the tilt can be detected from comparison of the potential difference between the track center and the VFO1 signal of read channel 2 (VFO potential-track center potential=Vpp1) with the potential difference between the track center and the VFO3 signal of read channel 2 (VFO3 potential-track

center potential=Vpp2).

That is, FIGS. 5a to 5c are exemplary diagrams showing read channel 2 signals detected under variation of tilt with the focus and tracking on. Referring to 5a to 5c, the left-hand signal is the read channel 2 signal detected at the VFO1 area of the header field and the right-hand signal is the read channel 2 signal detected at the VFO3 area of the header field. The voltage (V_{WC}) detected at the track center is the reference voltage.

In a case where tilt is zero, i.e., there is no radial tilt, the potential difference between the track center and the VFO1 signal ($Vpp1=V_{VFO1}-V_{WC}$) is almost is almost equal to the potential difference between the track center and the VFO3 signal ($VPP2= V_{VFO3}-V_{WC}$), as shown in FIG. 5b. This means, the potential difference ($Vpp1=V_{VFO1}-V_{WC}$) is in symmetric relation with the potential difference ($VPP2= V_{VFO3}-V_{WC}$).

This can be expressed by Equation 1.

[Equation 1]

$$V_{VFO1} - V_{WC} \approx V_{VFO3} - V_{WC}$$

The value V_{VFO1}/V_{VFO3} is determined while holding the peak and the bottom of the VFO1/VFO3 signal and then compared with the voltage of the track center.

In the potential difference Vpp1 between the VFO1 signal and the track center is not equal to the potential difference Vpp2 between the VFO3 signal and the track center, i.e., Vpp1 is in asymmetric relation with Vpp2, it means that tilt occurs.

For example, as shown in FIG. 5a, when $V_{VFO1} - V_{WC} > V_{VFO3} - V_{WC}$, i.e., Vpp1 > Vpp2, it means that tilt of about 1° occurs; and as shown in FIG. 5c, when $V_{VFO1} - V_{WC} < V_{VFO3} - V_{WC}$, i.e., Vpp1 < Vpp2, it means that tilt of about -1° occurs.

As such, the magnitude and the direction of tilt can be detected from calculation of the potential difference Vpp1 between the track center and the VFO1 signal and the potential difference Vpp2 between the track center and the VFO3 signal, and comparison of the two potential differences.

When the value Vpp1 - Vpp2 is α and the absolute value of α, the magnitude and the direction of tilt are detected from the value and the sign of α, respectively. That is, it can be known whether the disc is bending up or down with respect to a normal state.

If the sign of α is negative (-), tilt is to be compensated by α in the positive (+) direction; otherwise, if the sign of α is positive (+), tilt is to be compensated by α in the negative (-) direction. Therefore, compensation

for tilt has to be performed in such a direction as to equalize the two potential differences Vpp1 and Vpp2.

In connection with this, the tilt detector (204) outputs to the servo controller (205) tilt error signals indicating the magnitude and the direction of tilt, which correspond to the absolute value and the sign of α, respectively. The servo controller (205) converts the tilt error signals to a tilt driving signal and outputs the tilt driving signal to the tilt driver (206).

The tilt driver (206) moves the disc or the optical pickup for direct control of tilt based on the tilt driving signal, i.e., by the magnitude of tilt in the positive (+) or negative (-) direction.

Meanwhile, the present invention can detect the magnitude and the direction of tilt by using a ground level (also, called initial level) rather than the track center as the reference value for detecting tilt.

For this, the present invention can use either one of VFO1 and VFO2 signals of read channel 2 in the header field as well as both of them. Also, the present invention can use a voltage (V_{BOT1} or V_{BOT2}) while holding the bottom of read channel 2 signals in the header field, or a voltage (V_{TOP1} or V_{TOP2}) while holding the top of the read channel 2 signals.

For example, it is supposed that use is made of a

read channel 2 signal at the VFO1 area in the header field, particularly, a voltage obtained by holding the top of the read channel 2 signal at the VFO1 area.

First, a potential difference V_{TOP1} is measured between the ground potential when no tilt occurs and the top signal of the read channel 1 signal at the VFO1 area. If the potential difference V_{TOP1} is measured when no tilt occurs, as shown in FIG. 6b, tilt is detected with the potential difference used as a preset threshold.

That is, if the potential difference between the ground potential and the top signal of the read channel 2 signal at the VFO1 is not equal to the potential difference measured when no tilt occurs, it means that tilt has occurred.

It is determined that tilt has occurred, for example, if the potential difference V'_{TOP1} between the ground potential and the top signal of the read channel 2 signal at the VFO1 area is higher than the potential difference V_{TOP1} measured when no tilt occurs, as shown in FIG. 6a, or if the potential difference V''_{TOP1} between the ground potential and the top signal of the read channel 2 signal at the VFO1 area is lower than the potential difference V_{TOP1} measured when no tilt occurs, as shown in FIG. 6c.

The direction of tilt can be known from the sign of

the difference between the two potential differences. That is, the magnitude and the direction of tilt can be detected from the absolute value and the sign of the difference between the two potential differences.

For example, when VTOP1 - V″TOP1 = +β, which means that tilt has occurred by β, as shown in FIG. 6c, compensation for tilt has to be performed by β in the negative (-) direction.

The present invention also uses the potential difference V_{BOT1} as a reference value at the time when no tilt occurs and detects the magnitude and the direction of tilt using the relationship between the reference value and the potential difference between the ground potential and the bottom signal of the read channel 2 signal at the VFO1 area. Likewise, the present invention uses V_{TOP2} and V_{BOT2}.

Such as in the present invention, during tilt or servo control, the quantity of tilt between the optical axis and the disc plane can be detected and controlled by any one of the above-stated methods.

[EFFECT OF THE INVENTION]

According to a tilt controlling method of the present invention, by using the characteristic of read

channel 2 signals detected from the header 1 and 3 fields, especially, VFO1 and VFO3 areas of the header 1 and 3 fields, that the magnitude is constant but shifts above/below the track center, the magnitude and the direction of tilt can be detected and compensated. Therefore, tilt can be detected and compensated in a stable and accurate manner without using a separate light-receiving element in a high-density optical disc and deterioration of data quality caused by tilt during a recording/reproducing operation can be prevented and stable operation of the system can be possible.

It will be apparent to those skilled in the art than various modifications and variations can be made in the present invention.

Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is :

1. In a tilt controlling method of an optical recording/reproducing system in which a wobble signal is recorded on the boundary of tracks and header is staggered with respect to each other from the track center at the beginning position of each sector,

a tilt controlling method including the steps of:

determining a potential difference between the track center and a signal detected from a 1 header;

determining a potential difference between the track center and a signal detected from a 2 header staggered with the 1 header;

and detecting tilt value from the potential differences obtained at the above steps and performing a tilt servo based on the resulting value.

2. A tilt controlling method as claimed in claim 1, wherein the signal detected from the 1 header is a read channel 2 signal detected from VFO1 in a header 1 field.

3. A tilt controlling method as claimed in claim 1, wherein the signal detected from the 2 header is a read channel 2 signal detected from VFO3 in a header 3 field.

4. A tilt controlling method as claimed in claim 1, wherein the potential of the signal detected from the 1 and 2 headers is determined by holding the peak and bottom of read channel 2 signals detected in VFO areas in the header 1 and 3 fields, respectively.

5. A tilt controlling method as claimed in claim 1, wherein the potential of the signal detected from the 1 and 2 headers is determined by holding the center of read channel 2 signals detected in VFO areas in the header 1 and 3 fields, respectively.

6. A tilt controlling method as claimed in claim 1, wherein the potential of the track center is detected from a wobble signal detected from the read channel 2 signal.

7. A tilt controlling method as claimed in claim 1, wherein the tilt servo step is applied for compensating tilt by detecting the magnitude of tilt from the potential difference value between the 1 potential difference and the 2 potential difference obtained from the steps, respectively.

8. A tilt controlling method as claimed in claim 1, wherein the tilt servo step is applied for compensating

tilt by detecting the direction of tilt from the sign of the potential difference value between the 1 potential difference and the 2 potential difference obtained from the steps, respectively.

9. A tilt controlling method as claimed in claim 1, wherein the tilt servo step compensates tilt in a direction as to equalize the level of the 1 potential difference and the 2 potential difference.

10. In a tilt controlling method of an optical recording/reproducing system in which a wobble signal is recorded on the boundary of tracks and header is staggered with respect to each other from the track center at the beginning position of each sector,

a tilt controlling method including the steps of:

determining whether a read channel 2 signal detected from the 1 and 2 header is symmetric relation with respect to the track center value; and

performing a tilt servo based on the level of asymmetry if it is determined to be asymmetric at the above step.

11. A tilt controlling method as claimed in claim 10, wherein the determination step uses the read channel 2

signals detected from VFO areas of the header 1 field in the 1 header and the header 3 field in the 2 header for determining symmetry or asymmetry.

12. In a tilt controlling method of an optical recording/reproducing system in which a header field is pre-formatted at the beginning position of each sector,

a tilt controlling method including the steps of:

(a) obtaining potential difference between a ground level and a read channel 2 signal detected from the header field based on a status that tilt does not occurred and setting the potential difference as a reference value;

(b) obtaining potential difference between a ground level and a read channel 2 signal at need and comparing the potential difference with the reference value; and

(c) performing a tilt servo based on the resulting value from the step (b).

13. A tilt controlling method as claimed in claim 10, wherein the determination step uses the read channel 2 signals detected from VFO areas of the header 1 field in the 1 header and the header 3 field in the 2 header by holding the peak and bottom of the read channel 2 signals for determining symmetry or asymmetry.

14. A tilt controlling method as claimed in claim 10, wherein the determination step uses the read channel 2 signals detected from VFO areas of the header 1 field in the 1 header and the header 3 field in the 2 header by holding the center of the read channel 2 signals for determining symmetry or asymmetry.

15. A tilt controlling method as claimed in claim 10, wherein the determination step detects the potential of the track center used for determining symmetry or asymmetry from a wobble signal.

16. A tilt controlling method as claimed in claim 10, wherein the tilt servo step compensates tilt in a direction that the read channel 2 signal detected from the 1 and 2 header is in symmetric based on the value of the track center.

17. A tilt controlling method as claimed in claim 12, wherein the (a) and (b) steps respectively determine potential difference between a ground level and voltage obtained by holding the top of read channel 2 signals detected from VFO1 area of a header 1 field in the header region.

18. A tilt controlling method as claimed in claim 12, wherein the (a) and (b) steps respectively determine potential difference between a ground level and voltage obtained by holding the bottom of read channel 2 signals detected from VFO1 area of a header 1 field in the header region.

19. A tilt controlling method as claimed in claim 12, wherein the (a) and (b) steps respectively determine potential difference between a ground level and voltage obtained by holding the top of read channel 2 signals detected from VFO3 area of a header 3 field in the header region.

20. A tilt controlling method as claimed in claim 12, wherein the (a) and (b) steps respectively determine potential difference between a ground level and voltage obtained by holding the bottom of read channel 2 signals detected from VFO3 area of a header 3 field in the header region.

21. A tilt controlling method as claimed in claim 12, wherein the (c) step detects the magnitude of tilt from difference value of the potential differences obtained from the (a) and (b) steps and detects the

direction of tilt from the sign of the difference value and compensates tilt based on the resulting value.

22. A tilt controlling method as claimed in claim 12, wherein the (c) step compensates tilt in a direction as to equalize the level of the potential difference in the (b) step and the potential difference in the (c) step.

FIG. 1

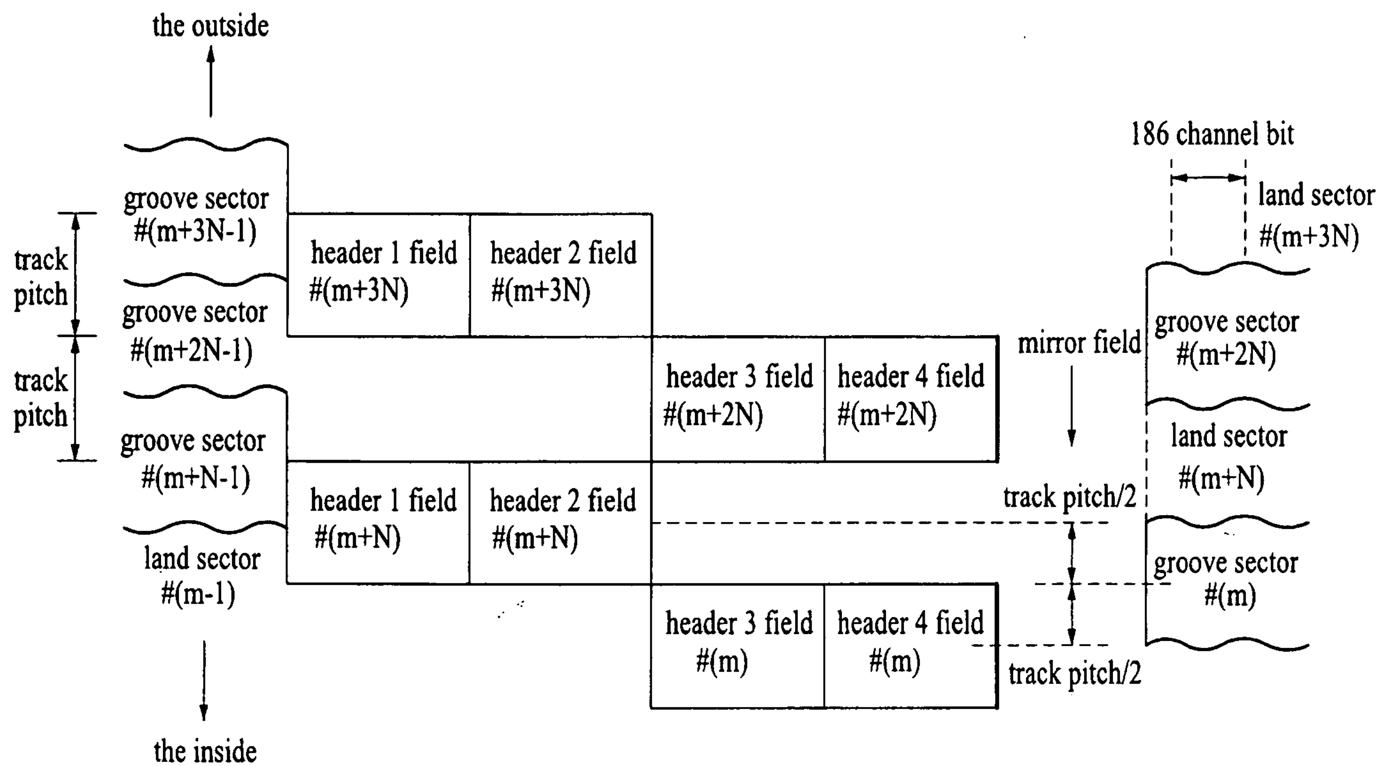

the outside
the inside
track pitch
track pitch
groove sector #(m+3N-1)
groove sector #(m+2N-1)
groove sector #(m+N-1)
land sector #(m-1)
header 1 field #(m+3N)
header 2 field #(m+3N)
header 1 field #(m+N)
header 2 field #(m+N)
header 3 field #(m+2N)
header 4 field #(m+2N)
header 3 field #(m)
header 4 field #(m)
mirror field
track pitch/2
track pitch/2
186 channel bit
land sector #(m+3N)
groove sector #(m+2N)
land sector #(m+N)
groove sector #(m)

FIG. 2

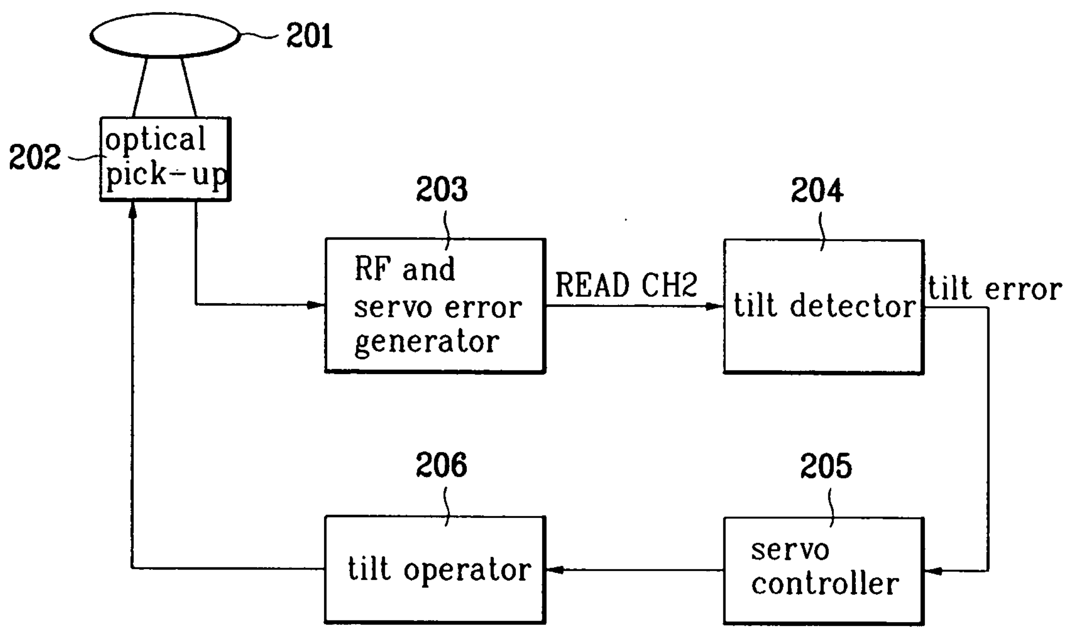

201
202
optical pick-up
203
RF and servo error generator
READ CH2
204
tilt detector
tilt error
206
tilt operator
205
servo controller

FIG. 3

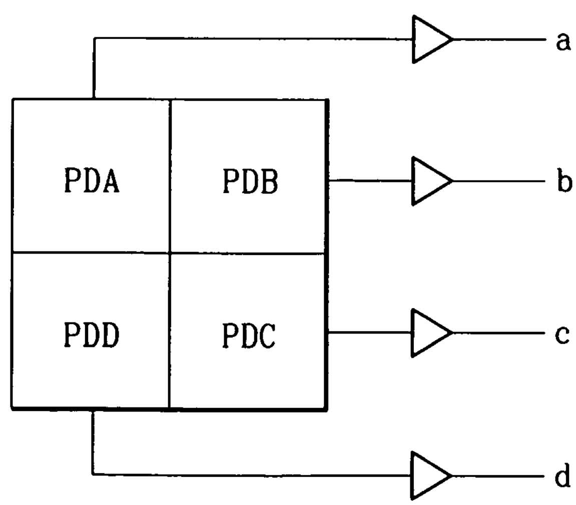

PDA
PDB
PDD
PDC
a
b
c
d

FIG. 4

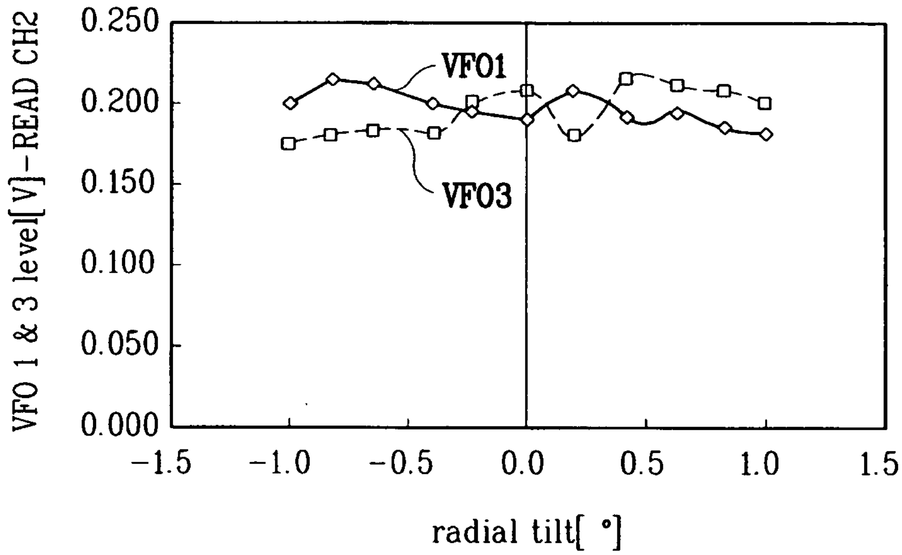
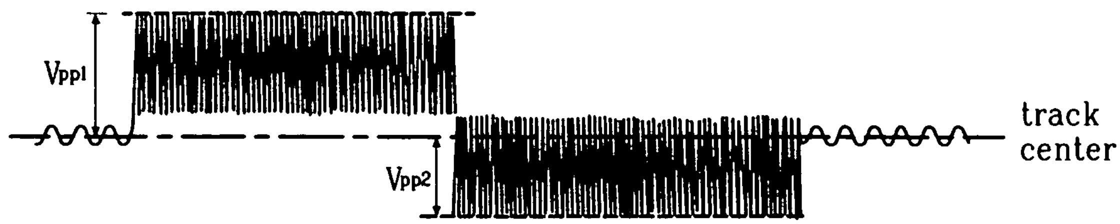
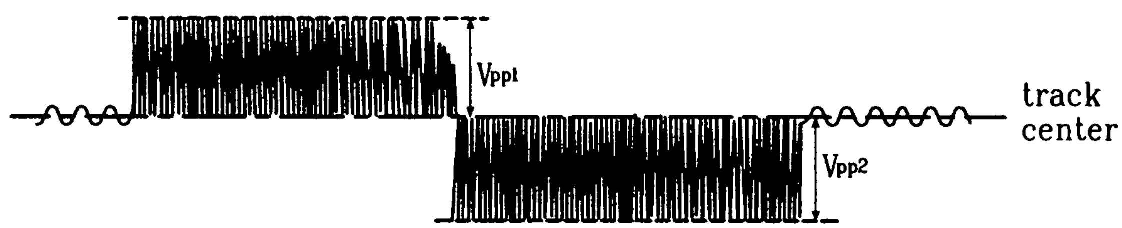

VFO 1 & 3 level[V]-READ CH2
0.250
0.200
0.150
0.100
0.050
0.000
VFO1
VFO3
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
radial tilt[°]

FIG. 5a



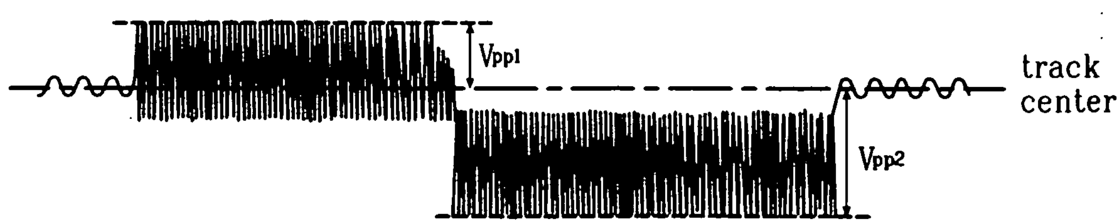
tilt=1, detrack offset=4.97
defocus offset=4.08

FIG. 5b



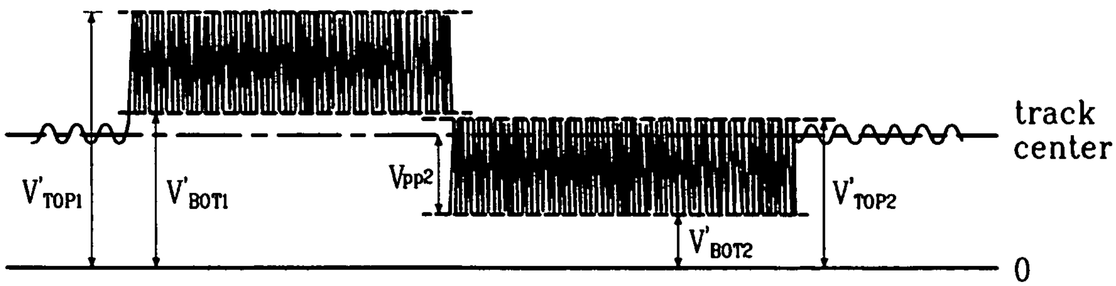
tilt=0, detrack offset=4.97
defocus offset=4.08

FIG. 5c



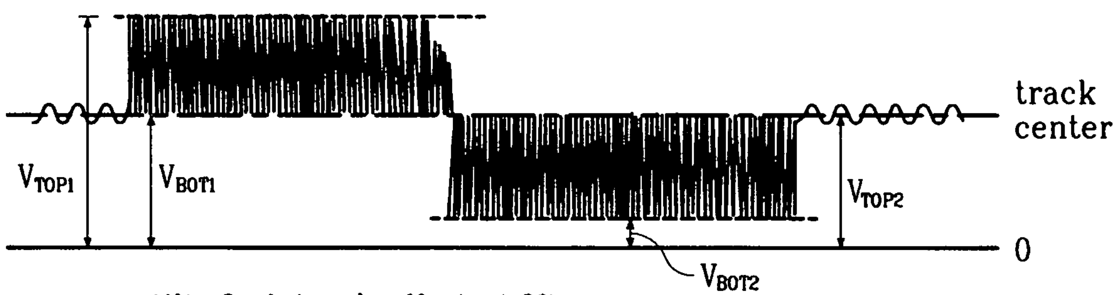
tilt=-1, detrack offset=4.97
defocus offset=4.08

FIG. 6a



tilt=1, detrack offset=4.97
defocus offset=4.08

FIG. 6b



tilt=0, detrack offset=4.97
defocus offset=4.08

FIG. 6c

tilt=−1, detrack offset=4.97
defocus offset=4.08